

JC10 Rec'd PC1/PTO 15 MAR 2002

DESCRIPTION

AQUEOUS INK AND PROCESS FOR PRODUCING DYE

Technical Field

The present invention relates to aqueous ink containing a dye, especially aqueous ink suitable for an ink jet recording system, and a simple process for producing a dye.

Background of the Invention

Aqueous ink used in writing instruments or for recording of an ink jet recording system is basically made of a dye, water and an organic solvent. In consideration of an odor and safe to the human body and the surrounding environment, aqueous ink containing water as a main solvent has been in high demand, and acid dyes, direct dyes and the like which are soluble in water have been actually used. In this connection, various characteristics are required for dyes and aqueous ink.

Especially, with respect to aqueous ink used in a recording liquid of an ink jet recording system, the following various characteristics are required. However, all these characteristics have not been satisfied at present.

(1) Physical properties such as viscosity, surface tension, specific conductivity, density, pH and the like of ink are appropriate.

(2) Long-term storage stability of ink is good.

(3) Dissolution stability of a soluble component is high and clogging of a nozzle does not occur.

(4) Quick-drying property of a recording medium is good.

(5) A recorded image is sharp without blotting, and light fastness, water resistance and moisture resistance are good.

As stated above, characteristics of ink used in an ink jet recording system in particular are greatly influenced by characteristics inherent in a dye. It is thus quite important to produce a dye and aqueous ink that satisfy these conditions.

Disclosure of the Invention

The invention aims to provide aqueous ink which has a high image quality without blotting, which is excellent in storage stability, light fastness, moisture resistance and jet stability and which is useful as a recording liquid of an ink jet recording system.

The present inventors have assiduously conducted investigations to solve these problems, and have consequently come to complete the invention.

That is, the invention relates to:

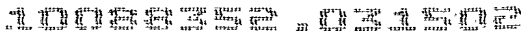
(1) aqueous ink for ink jet recording comprising a coloring matter and an aqueous medium as main components, in which at least one of dyes represented by the formula (A) or their salts is contained as the coloring matter.

2. 1

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[illegible]

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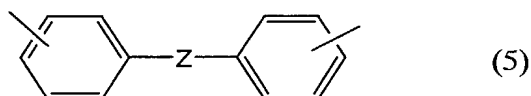
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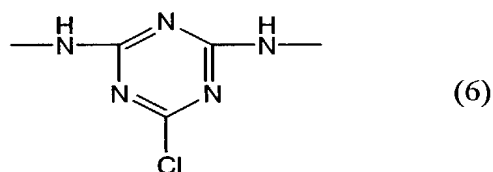
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by the formula (C) as recited in (7) or its salt in water and adjusting pH of the aqueous solution to 9 or more to remove insoluble matters formed with a water-soluble organic solvent to crystallize the dye,

(10) the process for producing the dye as recited in any of (7) to (9), wherein in the formula (C), X is an alkylene group, a phenylene group, a xylylene group, a naphthylene group, a biphenylene group or a divalent bonding group represented by the formula (5)



in which Z represents an oxygen atom, a sulfur atom, -CO-, -NHCONH-, -NHCSNH-, -CH=CH- or the formula (6)



(these bonding groups may be substituted with a halogen atom, an alkyl group, an alkoxy group, a hydroxyl group, an amino group, a carboxyl group or a sulfonic acid group),

(11) the process for producing the dye as recited in any of (7) to (9), wherein in the formula (C), X is an optionally substituted phenylene group,

(12) the process for producing the dye as recited in any of (7) to (9), wherein in the formula (C), A is a naphthyl group (the naphthyl group may be substituted with any of a halogen atom,

a hydroxyl group, an amino group, an optionally substituted alkyl group, an alkoxy group, a carboxyl group, a carboxylic acid ester group, a carboxylic acid amide group, a sulfonic acid group and a sulfonic acid amide group),

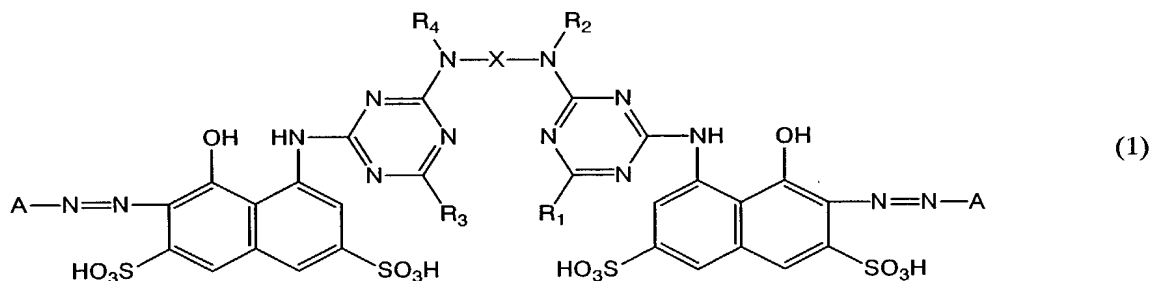
(13) the process for producing the dye as recited in any of (7) to (9), wherein the dye is the formula (B), and

(14) aqueous ink for ink jet recording characterized by containing at least one of the dyes produced by the process for producing the dye as recited in any of (7) to (13).

Best Mode for Carrying Out the Invention

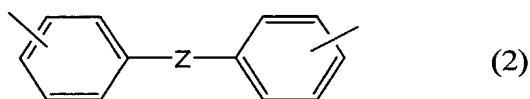
The dyes contained in the aqueous ink for ink jet recording in the invention are represented by the foregoing formula (A).

They are preferably dyes represented by the formula (1)

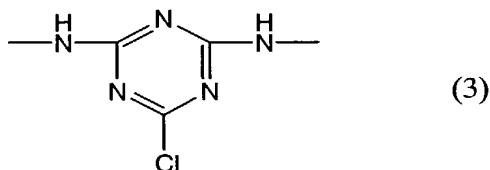


[wherein R_1 and R_3 , independently from each other, represent a hydrogen atom, a hydroxyl group or a halogen atom, R_2 and R_4 , independently from each other, represent a hydrogen atom, an optionally substituted alkyl group, an optionally substituted aryl group or an optionally substituted aralkyl group, A represents a phenyl group or a naphthyl group (the phenyl group

or the naphthyl group may be substituted with any of a halogen atom, a hydroxyl group, an amino group, an optionally substituted alkyl group, an alkoxy group, a carboxyl group, a carboxylic acid ester group, a carboxylic acid amide group, a sulfonic acid group and a sulfonic acid amide group), X represents an alkylene group, a phenylene group, a xylylene group, a naphthylene group, a biphenylene group or a divalent bonding group represented by the formula (2)



in which Z represents -CO-, -NHCONH-, -NHCSNH- or the formula (3)



(these bonding groups may be substituted with a halogen atom, an alkyl group, an alkoxy group, a hydroxyl group, an amino group, a carboxyl group or a sulfonic acid group)] or their salts.

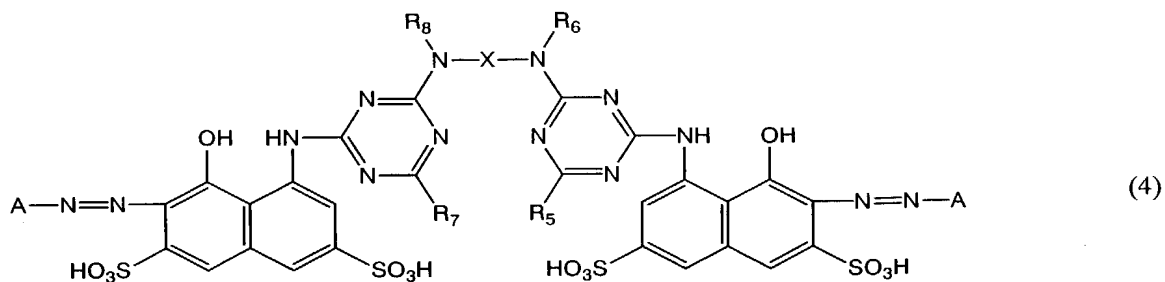
In these formulas (A) and (1), R_1 and R_3 , independently from each other, represent a hydrogen atom, a hydroxyl group or a halogen atom, R_2 and R_4 , independently from each other, represent a hydrogen atom, an optionally substituted alkyl group, an optionally substituted aryl group or an optionally substituted aralkyl group, A represents a phenyl group or a naphthyl group (which may be substituted with any of a halogen atom, a hydroxyl

group, an amino group, an optionally substituted alkyl group, an alkoxy group, a carboxyl group, a carboxylic acid ester group, a carboxylic acid amide group, a sulfonic acid group and a sulfonic acid amide group), and X represents an optionally substituted alkylene group, an optionally substituted phenylene group, an optionally substituted xylylene group, an optionally substituted naphthylene group or a divalent bonding group represented by the formula (2) (these bonding groups may be substituted with a halogen atom, an alkyl group, an alkoxy group, a hydroxyl group, an amino group, a carboxyl group or a sulfonic acid group).

In the divalent bonding group represented by the formula (2), Z represents -CO-, -NHCONH-, -NHCSNH- or the formula (3).

Further, in the formula (A), m and n, independently from each other, represent an integer of 1 to 4, and may be the same or different. Preferably, they are independently an integer of 2 or 3. Among others, a dye represented by the formula (1) in which m and n are both 2 or its salt is preferable.

In the dyes represented by the formula (C) which are contained in the aqueous ink of the invention, preferably dyes represented by the formula (4);



[wherein R_5 and R_7 , independently from each other, represent a hydrogen atom, an optionally substituted alkyl group, an optionally substituted alkoxy group, an amino group, an alkylamino group, a hydroxyl group or a halogen atom, R_6 and R_8 , independently from each other, represent a hydrogen atom, an optionally substituted alkyl group, an optionally substituted aryl group or an aralkyl group, A represents a phenyl group or a naphthyl group (the phenyl group or the naphthyl group may be substituted with any of a halogen atom, a hydroxyl group, an amino group, an optionally substituted alkyl group, an alkoxy group, a carboxyl group, a carboxylic acid ester group, a carboxylic acid amide group, a sulfonic acid group and a sulfonic acid amide group), and X represents a divalent bonding group] or their salts, R_5 and R_7 , independently from each other, represent a hydrogen atom, an alkoxy group, an amino group, a hydroxyl group or a halogen atom, R_6 and R_8 , independently from each other, represent a hydrogen atom, an optionally substituted alkyl group, an optionally substituted aryl group or an aralkyl group, A represents a phenyl group or a naphthyl group (which may be substituted with any of a halogen atom, a hydroxyl group, an amino group, an optionally substituted alkyl group, an alkoxy group, a carboxyl group, a carboxylic acid ester group, a carboxylic acid amide group, a sulfonic acid group and a sulfonic acid amide group), and X represents a divalent bonding group. Examples of X include an optionally substituted alkylene group, an optionally substituted

phenylene group, an optionally substituted xylylene group, an optionally substituted naphthylene group, a divalent bonding group represented by the formula (5) (these bonding groups may be substituted with a halogen atom, an alkyl group, an alkoxy group, a hydroxyl group, an amino group, a carboxyl group or a sulfonic acid group) and the like. In the divalent bonding group represented by the formula (5), Z represents -NHCONH-, -NHCSNH- or a bonding group represented by the formula (6).

In the foregoing formula (A), formula (1), formula (C), formula (4) and divalent bonding group, examples of the halogen atom include a fluorine atom, a chlorine atom, a bromine atom and an iodine atom.

Further, the carboxyl group and the sulfonic acid group may be in the form of a free radical or a salt. Examples of the salt include a carboxylic acid salt group which is a salt with an alkali metal, an amine or the like and a sulfonic acid salt group which is a salt with an alkali metal, an amine or the like.

The salt is not particularly limited. Examples thereof include alkali metal salts of a lithium atom, a sodium atom, a potassium atom and the like, ammonium salts, and organic amine salts of a primary amine, a secondary amine, a tertiary amine and the like.

The optionally substituted alkyl group is not particularly limited. It is an alkyl group having the total carbon number of 20 or less, preferably 15 or less. Specific examples thereof

include alkyl groups such as a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a tert-butyl group and the like, and halogenated alkyl groups such as a trifluoromethyl group, a chloroethyl group and the like.

The optionally substituted alkoxy group is not particularly limited. It is an alkoxy group having the total carbon number of 20 or less, preferably 15 or less. Specific examples thereof include a methoxy group, an ethoxy group, an n-propoxy group, an isopropoxy group, an n-butoxy group, an isobutoxy group, a tert-butoxy group and the like.

The optionally substituted aralkyl group is not particularly limited. It is an aralkyl group having the total carbon number of 20 or less, preferably 15 or less. Specific examples thereof include a benzyl group, a phenethyl group and the like.

The optionally substituted aryl group is not particularly limited. It is an aryl group having the total carbon number of 20 or less, preferably 15 or less. Specific examples thereof include an unsubstituted phenyl group, a halogen atom-substituted phenyl group such as a chlorophenyl group, a bromophenyl group, a fluorophenyl group or the like, a phenyl group substituted with at least one of alkyl groups such as a methyl group, an ethyl group, a propyl group, a butyl group and the like, a phenyl group substituted with a halogenoalkyl group such as a trifluoromethyl

group or the like, and a phenyl group substituted with at least one of a hydroxyl group, an amino group, a carboxyl group, a sulfonic acid group and the like.

The carboxylic acid ester group is not particularly limited. It is a carboxylic acid ester group having the total carbon number of 20 or less, preferably 15 or less. Specific examples thereof include alkoxycarbonyl groups such as a methoxycarbonyl group, an ethoxycarbonyl group, a propoxycarbonyl group, a butoxycarbonyl group and the like.

The carboxylic acid amide group is not particularly limited. It is a carboxylic acid amide group having the total carbon number of 20 or less, preferably 15 or less. Specific examples thereof include alkylaminocarbonyl groups such as an aminocarbonyl group, a methylaminocarbonyl group, an ethylaminocarbonyl group, a propylaminocarbonyl group, a butylaminocarbonyl group, a dimethylaminocarbonyl group, a diethylaminocarbonyl group, a diethanolaminocarbonyl group and the like.

The sulfonic acid amide group is not particularly limited. It is a sulfonic acid amide group having the total carbon number of 20 or less, preferably 15 or less. Specific examples thereof include alkylaminosulfonyl groups such as an aminosulfonyl group, a methylaminosulfonyl group, an ethylaminosulfonyl group, a propylaminosulfonyl group, a butylaminosulfonyl group, a dimethylaminosulfonyl group, a diethylaminosulfonyl group, a diethanolaminosulfonyl group and the like.

The optionally substituted alkylene group is not particularly limited. It is an alkylene group having the total carbon number of 20 or less, preferably 15 or less. Specific examples thereof include $-C_pH_{2p}$ (p represents an integer of 1 to 10). These may be substituted with a halogen atom, an alkyl group, an alkoxy group, a hydroxyl group, an amino group, a carboxyl group, a sulfonic acid group and the like.

The optionally substituted phenylene group is not particularly limited. Examples thereof include an unsubstituted phenylene group, and phenylene groups substituted with an alkyl group or a halogen atom such as a methyl group, an ethyl group, a methoxy group, an ethoxy group, fluorine, chlorine, bromine, iodide or the like, a carboxyl group, a sulfonic acid group, a hydroxyl group, an amino group and the like.

The optionally substituted xylylene group is not particularly limited. Examples thereof include an unsubstituted xylylene group, and xylylene groups substituted with an alkyl group or a halogen group such as a methyl group, an ethyl group, a methoxy group, an ethoxy group, fluorine, chlorine, bromine, iodine or the like, a carboxyl group, a sulfonic acid group, a hydroxyl group, an amino group and the like.

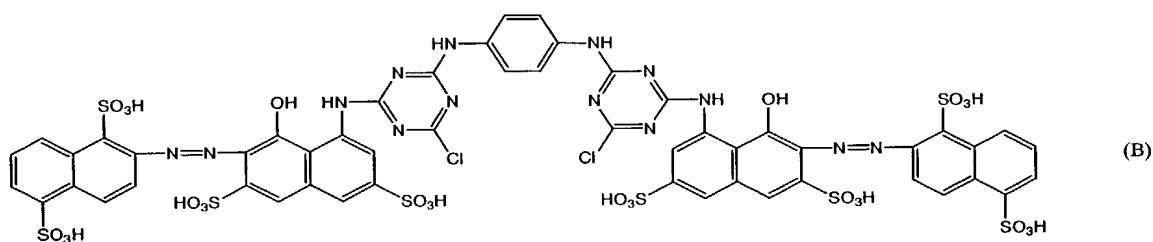
The optionally substituted naphthylene group is not particularly limited. Examples thereof include an unsubstituted naphthylene group, and naphthylene groups substituted with an alkyl group or a halogen atom such as a methyl group, an ethyl

group, a methoxy group, an ethoxy group, fluorine, chlorine, bromine, iodine or the like, a carboxyl group, a sulfonic acid group, a hydroxyl group, an amino group and the like. By the way, the bonding position of the divalent bonding group is not particularly limited. For example, in the optionally substituted phenylene group and xylylene group, it may be any of the o-position, the m-position and the p-position. In the optionally substituted naphthylene group, it may be any of the 1,5-position and the 2,6-position.

The dyes represented by the formula (A), formula (1), formula (C) and formula (4), which are used in the invention, may be in the form of a free acid or a salt. They may be used in any of these forms. Examples of the salt include alkali metal salts of sodium, potassium, lithium and the like, alkyl or hydroxylalkyl ammonium salts, and salts of organic amines such as ammonia, an alkylamine or a hydroxyalkylamine, a carboxy substituted amine and the like. These may be used as a single salt or a mixed compound of plural salts. They may be partially in the form of a free acid as such. Moreover, they may properly be subjected to salt exchange as required.

The dyes represented by the formula (A) and the preferable dyes represented by the formula (1), which are used in the invention, are those in which at least one of R_1 and R_3 is a halogen atom and X is an alkylene group, a phenylene group, a xylylene group, a naphthylene group or a divalent bonding group represented

both halogen atoms and X is an optionally substituted phenylene group (which may be substituted with a halogen atom, an alkyl group, an alkoxy group, a hydroxyl group, an amino group, a carboxyl group or a sulfonic acid group), preferably an unsubstituted phenylene group and A is an optionally substituted naphthyl group (the naphthyl group may be substituted with a halogen atom, a hydroxyl group, an amino group, an optionally substituted alkyl group, an alkoxy group, a carboxyl group, a carboxylic acid ester group, a carboxylic acid amide group, a sulfonic acid group or a sulfonic acid amide group), preferably a naphthyl group having a sulfone group. Especially preferable are dyes represented by the formula (B):



By the way, when the dye is used in ink, two or more of the dyes represented by the formula (A) may be contained. When two or more dyes are contained, it is especially preferable that the dye of the formula (B) is contained as one thereof. The mixing of two or more dyes including the same makes it possible to create a delicate color tone and conduct high-quality ink jet printing.

Specific examples of the dyes are shown in Table 1. However, they are not critical at all.

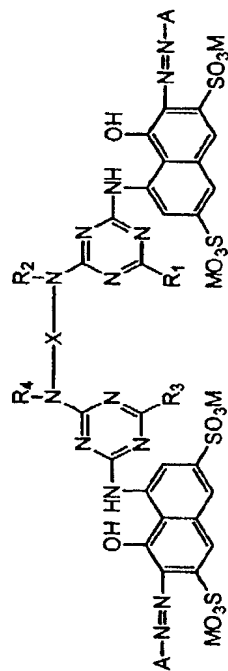


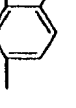
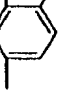
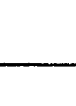
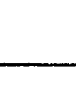


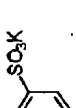
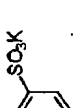

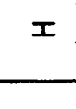
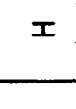
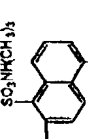
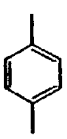
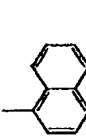
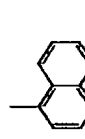
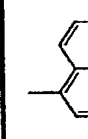
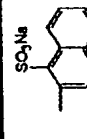
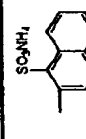
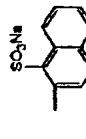
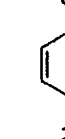


Table 1

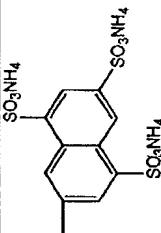
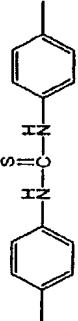
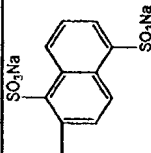
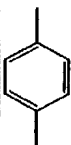
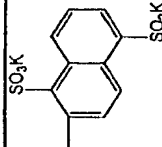
Dye No.	Structural Formula						
	R ₁	R ₂	R ₃	R ₄	A	M	X
1	Cl	H	Cl	H		Li	
2	Cl	H	Cl	H		Na	
3	Cl	H	OH	H	↑	Na	↑
4	Cl	H	OH	H		Na	↑
5	Cl	H	NH ₂	H		Na	↑

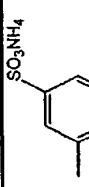
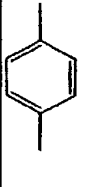
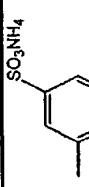
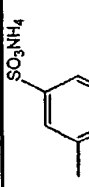
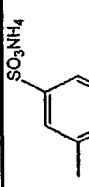
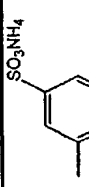
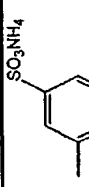
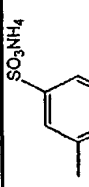
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7	Cl	H	Cl	H		NH4	
8	Cl	H	Cl	H		NH(C4H9)3	
9	Cl	H	Cl	H		NH(C2H4OH)3	
10	Cl	H	Cl	H		Na	
11	OH	H	OH	H		Na	↑
12	OH	H	OH	H		NH4	

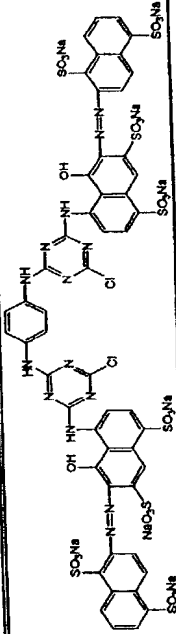
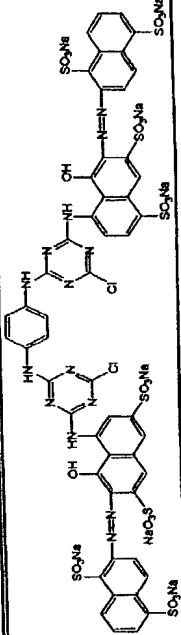
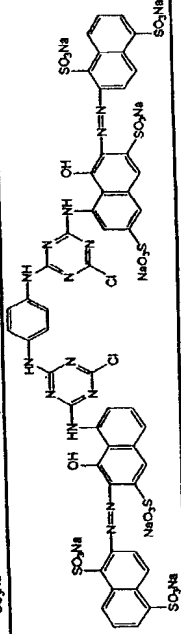
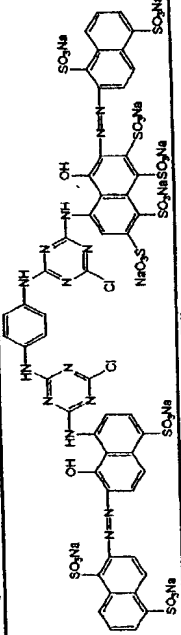
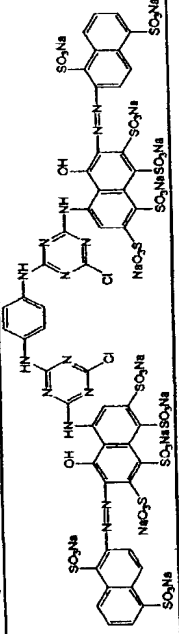
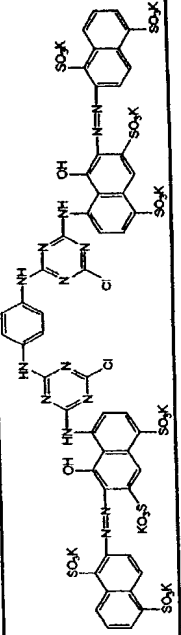
20	Cl	H	Cl	H		$\text{NH}(\text{CH}_2)_3$	
21	OH	H	OH	H		Na	↑
22	OH	H	OH	H		NH_4	↑
23	Cl	H	Cl	H		Na	↑
24	Cl	H	Cl	H		K	—C ₂ H ₄ —
25	Cl	H	Cl	H		NH_4	↑
26	Cl	H	Cl	H		Na	

27	Cl	H	Cl	H		Na	
28	Cl	H	Cl	H		Na	
29	Cl	H	Cl	H		Na	
30	Cl	H	Cl	H		Na	
31	Cl	H	Cl	H		Na	
32	Cl	H	Cl	H		Na	
33	Cl	H	Cl	H		Na	

34	Cl	H	Cl	H	↑	Na	
35	Cl	H	OH	H	↑	Na	
36	Cl	H	Cl	H		Na	↑
37	Cl	H	Cl	H		NH ₄	↑
38	Cl	H	Cl	H		Na	
39	Cl	H	Cl	H		NH(CH ₃) ₃	↑
40	Cl	H	Cl	H		NH ₄	↑

41	Cl	CH ₃	Cl	CH ₃	↑	NH ₄	↑
42	OH	H	OH	H	↑	NH ₄	↑
43	Cl	C ₃ H ₇	Cl	C ₃ H ₇		NH ₄	↑
44	Cl	H	Cl	H	↑	NH ₄	
45	Cl	H	Cl	H		Na	↑
46	Cl	H	Cl	H	↑	Na	
47	Cl	H	Cl	H		K	↑

48	Cl	CH ₃	Cl	CH ₃		NH ₄	
49	OH	H	OH	H		NH ₄	↑
50	Cl	C ₃ H ₇	Cl	C ₃ H ₇		NH ₄	↑
51	Cl	H	Cl	H		NH ₄	↑
52	Cl	H	Cl	H		Na	↑
53	Cl	H	Cl	H		Na	↑
54	Cl	H	Cl	H		K	↑

Dye No.	Structural Formula	Dye No.	Structural Formula
55		58	
56		59	
57		60	

A method for forming the dyes contained in the aqueous ink of the invention is not particularly limited. For example, the dyes can be formed according to a method described in Hosoda Yutaka, "RIRON SEIZO SENRYO KAGAKU 5th ed." (July 15, 1968, published by K.K. Gihodo).

For example, regarding dye No. 2 in Table 1, a solution (pH 6 to 6.5) of a sodium salt of H-acid in water is added dropwise to cyanuric chloride dispersed in water at 0 to 2°C over 1 hour. The product is precipitated with sodium chloride.

The precipitated product and sodium acetate are added to water, and a solution of a diazo compound of 2-aminonaphthalene-1,5-disulfonic acid is added to conduct azo coupling (the coupling reaction can be conducted according to a method described in, for example, Hosoda Yutaka, "RIRON SEIZO SENRYO KAGAKU 5th ed. "). After the reaction, the product is neutralized with a dilute solution of sodium carbonate to form a sodium salt. Sodium chloride is added to precipitate a monoazo dye. After separation by filtration, the monoazo dye is dissolved in water. To this solution is added a neutral aqueous solution of 0.5 equivalent of sodium 1,3-diaminobenzene-6-sulfonate at 40 to 45°C to conduct a reaction. The solution is precipitated with the addition of sodium chloride. Thus, dye No. 2 in Table 1 can be produced in the form of a sodium salt.

The aqueous ink of the invention is useful as various inks, especially a recording liquid of an ink jet recording system.

The dye can be used as such. Especially when it is used in a recording liquid of an ink jet recording system, it is advisable to remove or reduce impurities such as a starting material used for production of the dye, intermediates or byproducts formed during production, inorganic salts such as KCl, NaCl and Na₂SO₄, and the like for preventing clogging of a jet nozzle portion of a recording device by these impurities.

Removal or reduction of the impurities may be conducted, for example, with an ion exchange resin, by ultrafiltration or the like. However, these methods are problematic in that they take quite a long time, labor, costs and the like. According to the process for producing the dye in the invention, the dye formed is dissolved in water to give an aqueous solution which is then adjusted to pH of 9 or more, preferably 10 or more, whereby impurities contained in the dye, such as a starting material used for production of the dye, intermediates or byproducts formed during production and the like can be insolubilized and removed by filtration. At this time, it is preferable to use a filter aid in combination for increasing removal efficiency. Further, inorganic salts can be removed in a filtrate by mixing the aqueous solution of the dye with a water-soluble organic solvent to crystallize the dye and filtering the same. At this time, after the dye is dissolved in water, a water-soluble organic solvent may be added. Alternatively, the aqueous solution of the dye is charged into a water-soluble organic solvent for

crystallization. Either the step of removing the starting material used for production of the dye, the intermediates or the byproducts formed during production and the like or the step of removing the inorganic salts may be conducted earlier. Preferably, the step of removing the inorganic salts is conducted later. In the thus-obtained dye, it is preferable that the impurities are not precipitated at pH in using ink. The contents of the inorganic salts are preferably 5 % or less, more preferably 1 % or less, especially preferably 0.5 % or less. Consequently, clogging in a jet nozzle portion of ink produced using the dye can be suppressed.

Water used in production of the dye and production of the ink is not particularly limited. It is advisable that water less contains inorganic salts, inorganic ions and impurity components. Filtered water, deionized water, distilled water and the like are preferable.

The amount of water used in dissolving the dye in water varies with solubility of the dye and contents of inorganic materials and organic materials. It is usually 1 to 100 parts by weight per part by weight of the dye. The dissolution is conducted usually at room temperature. However, when the concentration of the dye is high or the solubility is low, it can be dissolved by heating. With respect to the heating temperature in this case, it is preferable that the heating is conducted at such a temperature that the dye is not decomposed.

In the adjustment of pH, for example, acetic acid, hydrochloric acid, sulfuric acid, nitric acid or the like can be used as an acid, and, for example, sodium hydroxide, potassium hydroxide, aqueous ammonia, tetramethylammonium hydroxide, tetrabutylammonium hydroxide or the like as a base. However, other materials are not problematic in particular.

The filter aid used is not particularly limited. Examples thereof include siliceous earth, sawdust, asbestos, paper pulp, activated carbon, Celite, talc and the like.

The amount of the water-soluble organic solvent used to remove inorganic salts varies with the concentration of the dye aqueous solution, the solubility of the dye and the contents of the impurities in the dye, and also varies with the contents of the impurities in the desired dye after production. It is usually 1 to 100 parts by weight per part by weight of the dye. The water-soluble organic solvent having the low solubility of the dye is preferable. Examples thereof include polyhydric alcohols such as ethylene glycol, diethylene glycol, triethylene glycol, polyethylene glycol, propylene glycol, polypropylene glycol, 1,3-propanediol, glycerin, thioglycol and the like, polyhydric alcohol ethers such as ethylene glycol monoethyl ether, ethylene glycol monobutyl ether, diethylene glycol monobutyl ether, dipropylene glycol monoethyl ether, triethylene glycol monomethyl ether and the like, ketones such as acetone, methyl ethyl ketone and the like, amides such as N,N-dimethylformamide,

N,N-diethylformamide, N,N-dimethylacetamide and the like, nitrogen-containing compounds such as 2-pyrrolidone, N-methyl-2-pyrrolidone, N-vinyl-2-pyrrolidone, 1,3-dimethyl-2-imidazolidinone and the like, ethers such as tetrahydrofuran, dioxane and the like, alcohols such as methanol, ethanol, 1-propanol, 2-propanol, 1-butanol, 2-butanol and the like, and so forth. Preferable are alcohols, polyhydric alcohols and ketones. These water-soluble organic solvents may be used singly or in combination.

Further, with respect to dyes having low crystallinity in crystallizing the same for removal of inorganic salts, additives can also be added in view of acceleration of crystallization unless properties of dyes after purification are decreased.

Moreover, for adjusting the color tone of the ink and

improving the other properties, it is also possible to add known dyes or pigments formed in emulsion or fine dispersion unless the properties of the ink are impaired.

Examples of the water-soluble organic solvent incorporated in the aqueous ink of the invention include polyhydric alcohols such as ethylene glycol, diethylene glycol, triethylene glycol, polyethylene glycol, propylene glycol, polypropylene glycol, 1,3-propanediol, glycerin, thioglycol and the like, polyhydric alcohol ethers such as ethylene glycol monoethyl ether, ethylene glycol monobutyl ether, diethylene glycol monobutyl ether, dipropylene glycol monoethyl ether, triethylene glycol monomethyl ether and the like, ketones such as acetone, methyl ethyl ketone and the like, amides such as N,N-dimethylformamide, N,N-diethylformamide, N,N-dimethylacetamide and the like, nitrogen-containing compounds such as 2-pyrrolidone, N-methyl-2-pyrrolidone, N-vinyl-2-pyrrolidone, 1,3-dimethyl-2-imidazolidinone and the like, ethers such as tetrahydrofuran, dioxane and the like, alcohols such as methanol, ethanol, 1-propanol, 2-propanol, 1-butanol, 2-butanol and the like, and so forth. These water-soluble organic solvents may be used singly or in combination, and the content thereof is 0 to 80 % by weight, preferably 5 to 50 % by weight.

Further, for improving properties (for example, water resistance) of the ink, pH of the ink is preferably 8 or more.

Still further, for more improving water resistance, it is

advisable to use amines such as ammonia and the like and hydroxyamines such as triethanolamine and the like in combination. The contents are preferably 0.001 to 10 % by weight based on the ink. Besides, these amines may be used by forming counter ions with the dye.

Furthermore, urea, thiourea, biuret, semicarbamide or derivatives thereof may be used in combination with the ink containing the dye in the invention. The content thereof is preferably 0.1 to 15 % by weight based on the aqueous ink.

Moreover, various additives used so far can be added, as required, to the aqueous ink of the invention. Examples thereof include an ultraviolet absorber, an antioxidant, a chelating agent, a water-soluble polymer, a masking agent, a rust-proofing agent, a preservative, a viscosity modifier, a surfactant, a surface tension modifier, a pH adjustor, a specific resistance modifier, a near infrared absorber, a penetrant and the like.

The aqueous ink of the invention is produced by dissolving the dye along with water, the organic solvent and, as required, the foregoing additives. The thus-produced aqueous ink is excellent in recording characteristics, storage stability, fixability onto a recording medium, sharpness of a recorded image, light fastness, moisture resistance and the like as ink of writing instruments and the like or as ink of an ink jet recording system. It is especially useful as a recording liquid of an ink jet recording system, and further used also as ink of writing instruments such

as a ball point pen, a felt tipped pen, a fountain pen and the like.

Examples

The invention is illustrated more specifically below by referring to Examples. However, the invention is not limited to the following Examples. Incidentally, "part(s)" indicates part(s) by weight.

Example 1

<Production of a dye>

Five parts of dye No. 46 in Table 1 was dissolved in 20 parts of distilled water. This dye aqueous solution was charged into 10 parts of isopropyl alcohol to crystallize the dye. The mixture was filtered, and dried to obtain 3 parts of a purified product of dye No. 46 in Table 1. Analytical values of the dye are shown in Table 2. As a result, the content of an inorganic salt such as NaCl or the like was decreased, and the usable dye was formed by a simple process of production and purification.

Table 2

	Content (%) of NaCl
Dye No. 46 in Table 1 before purification	15.5
Dye No. 46 in Table 1 after purification	0.8

<Production of ink>

According to a formulation shown below, the compounds were mixed and dissolved, and the mixture was filtered with a Teflon filter having a pore diameter of 0.45 micron to produce ink.

<Formulation of ink>

dye No. 46 in Table 1 after purification	3 parts
diethylene glycol	30 parts
N-methyl-2-pyrrolidone	10 parts
deionized water	57 parts

<Evaluation of properties>

The above-produced ink was used, and filled in an ink cartridge for a piezo-type ink jet printer, and printing and image recording were conducted with the same printer. The test was conducted on the following items. The results were good, namely, (A) evaluation of an image; ◎, (B) evaluation of moisture resistance; ◎, (C) evaluation of light fastness; ◎, (D) evaluation of storage stability of ink; ○ and (E) evaluation of a state of a printer nozzle; ○.

Meanwhile, ink was likewise produced using a dye containing large amounts of inorganic salts before production, and likewise evaluated. The results were (A) evaluation of an image; ○, (B) evaluation of moisture resistance; ◎, (C) evaluation of light fastness; ◎, (D) evaluation of storage stability of ink; △ and (E) evaluation of a state of a printer nozzle; ×.

Incidentally, the ink containing the dye in which inorganic salts were reduced by the simple process of the present application

was, when used in an ink jet recording liquid in particular, excellent in storage stability of ink and jet stability from a printer nozzle.

Evaluation standards of the respective test items are as follows.

(A) Evaluation of an image

An image was formed on a plain paper, and a blotting condition was visually evaluated.

[Evaluation standard]

Blotting is not observed ; ◎

Blotting is slightly observed without any influence on an image ; ○

Blotting is notably observed ; ×

(B) Evaluation of moisture resistance

An image-recorded plain paper was allowed to stand under conditions of 40°C and humidity of 85 % for a fixed period of time, and a condition of the recorded image was visually observed to evaluate moisture resistance.

[Evaluation standard]

An image is unchanged after the paper is allowed to stand for 48 hours ; ◎,

An image is unchanged after the paper is allowed to stand for 24 hours, and a coloring matter is bled in an edge portion of the recorded image after the paper is allowed to stand for 48 hours ; ○

An insoluble matter appeared after 1 month, which is
problematic in use ; ×.

(E) Evaluation of a condition of a printer nozzle

After printing with a piezo-type ink jet printer, a condition
of a nozzle was visually observed.

[Evaluation standard]

Normal ; ○

An adherent matter is slightly observed, which is not
problematic in use, though ; △

An adherent matter is observed, which is problematic in
use ; ×.

Example 2

<Production of a dye>

Five parts of dye No. 30 in Table 1 was dissolved in 20
parts of distilled water. To this dye aqueous solution was added
dropwise 10 parts of acetone to crystallize the dye. The mixture
was filtered, and dried to obtain 3 parts of a purified product
of dye No. 30 in Table 1. Analytical values of the dye are shown
in Table 3. As a result, the content of an inorganic salt such
as NaCl or the like was decreased, and the usable dye was formed
by the simple process of production and purification.

[illegible][illegible][illegible][illegible][illegible][illegible][illegible][illegible][illegible][illegible]

evaluation of moisture resistance; ◎, (C) evaluation of light fastness; ◎, (D) evaluation of storage stability of ink; △ and (E) evaluation of a state of a printer nozzle; ×.

Incidentally, the ink containing the dye in which inorganic salts were reduced by the simple process of the application was, when used in an ink jet recording liquid in particular, excellent in storage stability of ink and jet stability from a printer nozzle.

Examples 3 to 37

Production of dyes and production of inks were conducted by the processes described in Example 1 using dyes shown in Table 1. The results are shown in Table 4.

Example 38

<Production of a dye>

Five parts of dye No. 46 in Table 1 was dissolved in 20 parts of distilled water. While this dye aqueous solution was stirred, a 10%-sodium hydroxide aqueous solution was added until pH reached 10. After the solution was stirred for 1 hour, 2 parts of activated carbon was added, and stirring was further conducted for 1 hour. Subsequently, the mixture was filtered with filter paper No. 5C, and a filtrate was charged into 10 parts of isopropyl alcohol to crystallize the dye. The mixture was filtered, and dried to obtain 3 parts of a purified product of dye No. 46 in Table 1. Analytical values of the dye are shown in Table 5. As a result, the content of an inorganic salt such as NaCl or the like was decreased, and impurities such as a starting material used for production of the dye, intermediates or byproducts formed during production and the like were also removed. Thus, the usable dye was formed by the simple process of production and purification.

Table 5

	Content (%) of NaCl
Dye No. 46 in Table 1 before purification	15.5
Dye No. 46 in Table 1 after purification	0.7

<Production of ink>

According to a formulation shown below, the compounds were

mixed and dissolved, and the mixture was filtered with a Teflon filter having a pore diameter of 0.45 micron to produce ink.

<Formulation of ink>

dye No. 46 in Table 1 after purification	3 parts
diethylene glycol	30 parts
N-methyl-2-pyrrolidone	10 parts
deionized water	57 parts

<Evaluation of properties>

Properties were evaluated by the methods described in Example 1 using the foregoing ink. The results were good, namely, (A) evaluation of an image; ◎, (B) evaluation of moisture resistance; ◎, (C) evaluation of light fastness; ◎, (D) evaluation of storage stability of ink; ◎ and (E) evaluation of a state of a printer nozzle; ○.

Meanwhile, ink was likewise produced using a dye containing large amounts of a starting material, intermediates, byproducts and inorganic salts before production, and likewise evaluated. The results were (A) evaluation of an image; ○, (B) evaluation of moisture resistance; ◎, (C) evaluation of light fastness; ◎, (D) evaluation of storage stability of ink; △ and (E) evaluation of a state of a printer nozzle; ×.

Incidentally, the ink containing the dye produced by the simple process of the application was, when used in an ink jet recording liquid in particular, excellent in storage stability of ink and jet stability from a printer nozzle.

Example 39

<Production of a dye>

Five parts of dye No. 46 in Table 1 was dissolved in 20 parts of distilled water. While this dye aqueous solution was stirred, a 10%-sodium hydroxide aqueous solution was added until pH reached 10. After the solution was stirred for 1 hour, 2 parts of Celite was added, and stirring was further conducted for 1 hour. Subsequently, the mixture was filtered with filter paper No. 5C, and a filtrate was charged into 10 parts of isopropyl alcohol to crystallize the dye. The mixture was filtered, and dried to obtain 3 parts of a purified product of dye No. 46 in Table 1. Analytical values of the dye are shown in Table 6. As a result, the content of an inorganic salt such as NaCl or the like was decreased, and impurities such as a starting material used in production of the dye, intermediates or byproducts formed during production and the like were removed. Thus, the usable dye was formed by the simple process of production and purification.

Table 6

	Content (%) of NaCl
Dye No. 46 in Table 1 before purification	15.5
Dye No. 46 in Table 1 after purification	0.6

<Production of ink>

According to a formulation shown below, the compounds were mixed and dissolved, and the mixture was filtered with a Teflon filter having a pore diameter of 0.45 micron to produce ink.

<Formulation of ink>

dye No. 46 in Table 1 after purification	3 parts
diethylene glycol	30 parts
N-methyl-2-pyrrolidone	10 parts
deionized water	57 parts

<Evaluation of properties>

Properties were evaluated by the methods described in Example 1 using the foregoing ink. The results were good, namely, (A) evaluation of an image; ◎, (B) evaluation of moisture resistance; ◎, (C) evaluation of light fastness; ◎, (D) evaluation of storage stability of ink; ◎ and (E) evaluation of a state of a printer nozzle; ○.

Meanwhile, ink was likewise produced using a dye containing large amounts of a starting material, intermediates, byproducts and inorganic salts before production, and likewise evaluated. The results were (A) evaluation of an image; ○, (B) evaluation of moisture resistance; ◎, (C) evaluation of light fastness; ◎, (D) evaluation of storage stability of ink; △ and (E) evaluation of a state of a printer nozzle; ×.

Incidentally, the ink containing the dye produced by the simple process of the application was, when used in an ink jet recording liquid in particular, excellent in storage stability

of ink and jet stability from a printer nozzle.

Example 40

<Production of a dye>

Five parts of dye No. 30 in Table 1 was dissolved in 20 parts of distilled water. While this dye aqueous solution was stirred, a 10%-sodium hydroxide aqueous solution was added until pH reached 10. After the solution was stirred for 1 hour, 2 parts of diatomaceous earth was added, and stirring was further conducted for 1 hour. Subsequently, the mixture was filtered with filter paper No. 5C, and 10 parts of acetone was added dropwise to a filtrate to crystallize the dye. The mixture was filtered, and dried to obtain 3 parts of a purified product of dye No. 30 in Table 1. Analytical values of the dye are shown in Table 7. As a result, the content of an inorganic salt such as NaCl or the like was decreased, and impurities such as a starting material used for production of the dye, intermediates or byproducts formed during production and the like were removed. Thus, the usable dye was formed by the simple process of production and purification.

Table 7

	Content(%) of NaCl
Dye No. 30 in Table 1 before purification	10.4
Dye No. 30 in Table 1 after purification	0.5

<Production of ink>

According to a formulation shown below, the compounds were mixed and dissolved, and the mixture was filtered with a membrane filter having a pore diameter of 0.45 micron to produce ink.

<Formulation of ink>

dye No. 30 in Table 1 after purification	3 parts
triethylamine	1 part
diethylene glycol	30 parts
N-methyl-2-pyrrolidone	10 parts
deionized water	56 parts

<Evaluation of properties>

Properties were evaluated by the methods described in Example 1 using the foregoing ink. The results were good, namely, (A) evaluation of an image; ◎, (B) evaluation of moisture resistance; ◎, (C) evaluation of light fastness; ◎, (D) evaluation of storage stability of ink; ◎ and (E) evaluation of a state of a printer nozzle; ○.

Meanwhile, ink was likewise produced using a dye containing large amounts of a starting material, intermediates, byproducts and inorganic salts before production, and likewise evaluated. The results were (A) evaluation of an image; ○, (B) evaluation of moisture resistance; ◎, (C) evaluation of light fastness; ◎, (D) evaluation of storage stability of ink; △ and (E) evaluation of a state of a printer nozzle; ×.

Incidentally, the ink containing the dye produced by the simple process of the application was, when used in an ink jet

recording liquid in particular, excellent in storage stability of ink and jet stability from a printer nozzle.

Example 41

<Production of a dye>

Five parts of dye No. 30 in Table 1 was dissolved in 20 parts of distilled water. While this dye aqueous solution was stirred, a 10%-sodium hydroxide aqueous solution was added until pH reached 10. After the solution was stirred for 1 hour, 2 parts of diatomaceous earth was added, and stirring was further conducted for 1 hour. Subsequently, the mixture was filtered with filter paper No. 5C to obtain a dye aqueous solution having a concentration of approximately 20 %. As a result, impurities such as a starting material used for production of the dye, intermediates or byproducts formed during production and the like were removed, and the usable dye was formed by the simple process of production and purification.

<Production of ink>

According to a formulation shown below, the compounds were mixed and dissolved, and the mixture was filtered with a membrane filter having a pore diameter of 0.45 micron to produce ink.

<Formulation of ink>

20 % aqueous solution of dye No. 30 in Table 1 after purification	15 parts
triethylamine	1 part
diethylene glycol	30 parts

N-methyl-2-pyrrolidone	10 parts
deionized water	44 parts

<Evaluation of properties>

Properties were evaluated by the methods described in Example 1 using the foregoing ink. The results were good, namely, (A) evaluation of an image; ◎, (B) evaluation of moisture resistance; ◎, (C) evaluation of light fastness; ◎, (D) evaluation of storage stability of ink; ○ and (E) evaluation of a state of a printer nozzle; ○.

Meanwhile, ink was likewise produced using a dye containing large amounts of a starting material, intermediates, byproducts and inorganic salts before production, and likewise evaluated. The results were (A) evaluation of an image; ○, (B) evaluation of moisture resistance; ◎, (C) evaluation of light fastness; ◎, (D) evaluation of storage stability of ink; △ and (E) evaluation of a state of a printer nozzle; ×.

Incidentally, the ink containing the dye produced by the simple process of the application was, when used in an ink jet recording liquid in particular, excellent in storage stability of ink and jet stability from a printer nozzle.

Examples 42 to 70

Production of dyes and production of inks were conducted by the processes described in Example 38 using dyes shown in Table 1. The results are shown in Table 8.

Table 8

filtered with a Teflon filter having a pore diameter of 0.45 micron to produce ink.

<Formulation of ink>

dye No. 46 in Table 1 after purification	1.5 parts
dye No. 30 in Table 1 after purification	1.5 parts
diethylene glycol	30 parts
N-methyl-2-pyrrolidone	10 parts
deionized water	57 parts

<Evaluation of properties>

Properties were evaluated by the methods described in Example 1 using the foregoing ink. The results were good, namely, (A) evaluation of an image; ◎, (B) evaluation of moisture resistance; ◎, (C) evaluation of light fastness; ◎, (D) evaluation of storage stability of ink; ○ and (E) evaluation of a state of a printer nozzle; ○.

Meanwhile, ink was produced in the foregoing manner except using dye No. 30 and No. 46 in Table 1 before purification containing large amounts of inorganic salts before production, and likewise evaluated. The results were (A) evaluation of an image; ○, (B) evaluation of moisture resistance; ◎, (C) evaluation of light fastness; ◎, (D) evaluation of storage stability of ink; △ and (E) evaluation of a state of a printer nozzle; ×.

Incidentally, the ink containing the dye in which the impurities were reduced by the simple process of the invention

was, when used in an ink jet recording liquid in particular, excellent in storage stability of ink and jet stability from a printer nozzle.

Incidentally, a color tone was evaluated according to JIS Z-8729. Consequently, the ink had a delicately different color tone in comparison with the ink made of dye No. 46 or 30 in Table 1 alone.

Example 72

<Production of ink>

According to the following formulation using dye No. 46 in Table 1 after purification as produced in Example 39 and dye No. 30 in Table 1 after purification as produced in Example 40, the compounds were mixed and dissolved, and the mixture was filtered with a Teflon filter having a pore diameter of 0.45 micron to produce ink.

<Formulation of ink>

dye No. 46 in Table 1 after purification	1.5 parts
dye No. 30 in Table 1 after purification	1.5 parts
diethylene glycol	30 parts
N-methyl-2-pyrrolidone	10 parts
deionized water	57 parts

<Evaluation of properties>

Properties were evaluated by the methods described in Example 1 using the foregoing ink. The results were good, namely, (A) evaluation of an image; ©, (B) evaluation of moisture

resistance; ◎, (C) evaluation of light fastness; ◎, (D) evaluation of storage stability of ink; ◎ and (E) evaluation of a state of a printer nozzle; ○.

Meanwhile, ink was produced in the foregoing manner using a mixed dye according to the foregoing formulation except using dye No. 30 and No. 46 in Table 1 before purification containing large amounts of inorganic salts before production, and likewise evaluated. The results were (A) evaluation of an image; ○, (B) evaluation of moisture resistance; ◎, (C) evaluation of light fastness; ◎, (D) evaluation of storage stability of ink; △ and (E) evaluation of a state of a printer nozzle; ×.

Incidentally, the ink containing the dyes produced by the simple process of the invention was, when used in an ink jet recording liquid in particular, excellent in storage stability of ink and jet stability from a printer nozzle.

Incidentally, a color tone was evaluated according to JIS Z-8729. Consequently, the ink had a delicately different color tone in comparison with the ink made of dye No. 46 or 30 in Table 1 alone.

Comparative Example 1

<Production of a dye with an organic solvent>

Dye No. 46 in Table 1 was used, and dissolved in an organic solvent according to an inorganic salt removal method. Thus, the dye was produced by a method to reduce inorganic salts and the like. Five parts of dye No. 46 in Table 1 was added to 50

parts of N,N-dimethylformamide. However, the dye was not dissolved. The dye in a dispersed state was separated by filtration, and dried. Analytical values of the dye are shown in Table 10. As a result, the content of an inorganic salt such as NaCl or the like was not reduced, and further, impurities such as a starting material used for production of the dye, intermediates or byproducts formed during production and the like could not be reduced either. Thus, the dye could not be produced by the simple process of the invention.

Table 10

	Content (%) of NaCl
Dye No. 46 in Table 1 before purification	15.5
Dye No. 46 in Table 1 after purification	15.4

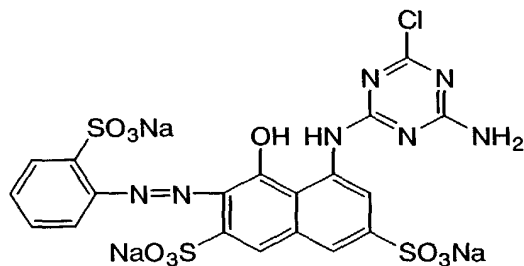
Moreover, a dissolution test was performed using other organic solvents. However, the dye was not dissolved either as in using N,N-dimethylformamide. This is because the dye possesses such qualities that it has high solubility in water but almost no solubility in an organic solvent. Thus, production was impossible by a method of dissolving a dye in an organic solvent to remove inorganic salts, which is a general method.

Comparative Example 2

<Production of a dye with an organic solvent>

Five parts of a dye represented by formula (d) was added

to 50 parts of N,N-dimethylformamide, and dissolved therein. An insoluble matter was separated by filtration, and a filtrate was dried. As a result, 2 parts of the dye purified with the organic solvent was obtained. Analytical values of the dye are shown in Table 11. Consequently, the content of an inorganic salt such as NaCl or the like was reduced.



(d)

Table 11

	Content (%) of NaCl
Dye of the formula (d) before purification	20.5
Dye of the formula (d) after purification	3.5

Ink was produced according to the process for producing ink in Example 1 using 5 parts of the dye of formula (d) after purification as produced above, and properties were likewise evaluated. The results were extremely bad in comparison with the aqueous ink of the invention, namely, (A) evaluation of an image; ○, (B) evaluation of moisture resistance; ×, (C) evaluation of light fastness; △, (D) evaluation of storage

stability of ink; ○ and (E) evaluation of a state of a printer nozzle; △.

Industrial Applicability

The aqueous ink containing the dye produced by the simple process of the invention exhibits excellent properties in light fastness, moisture resistance and storage stability. When the ink was used in a recording liquid of an ink jet recording system, it is important that contents of inorganic salts are minimized and impurities such as intermediates or byproducts formed during production and the like are also reduced. They can be attained by the process of the invention simply and effectively. Consequently, the aqueous ink can be provided in which clogging of a printer head is eliminated, formation of a high-quality image without blotting is enabled and a recorded image has also excellent properties in light fastness, moisture resistance and storage stability.